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Discourse Generation, Temporal Constraints, and Defeasible Reasoning*

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Introduction

Given the causal and temporal relations between events in a knowledge base, what are the ways they can be described in text?

Elsewhere, we have argued that defeasible reasoning underlies the hearer's temporal interpretation of text. Here, we argue, on the basis of the kind of temporal information that remains implicit in candidate utterances, that if the speaker is to tailor text to the hearer, then defeasible reasoning must be integrated into the generation process. We suggest two ways in which this can be done: a version of Hobbs et al's [1988, 1990] Generation as Abduction, and the Interactive Defaults Strategy introduced by Joshi et al [1984, 1986]. Assuming the Interactive Defaults strategy, the basic goal is to determine how notions of temporal reliability, precision and coherence can be used by a nonmonotonic logic to constrain the space of possible utterances. We explore a defeasible reasoning framework in which the interactions between the relative knowledge bases of speakers and hearers helps do this. Finally, we briefly discuss an objection to the programme as outlined, considering whether discourse structure has been marginalised.

To motivate the discussion, let us consider why we might want to generate discourses with structures which lead to temporal complexities.

Getting Things Out of Order

Consider the following suggestion for generating textual descriptions of causal-temporal structures. Describe things in exactly the order in which they happened. Make textual order match eventual order, and little can go wrong; the hearer can safely assume that all the texts they hear are narrative. Under these circumstances, the problem of choosing the adequate locations in utterance space pretty much dissolves. We do not believe that this suggestion will work, in general, and consider here two arguments against it.

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Hovy's argument

Basically, the suggestion canvassed above fails to emphasise the force of some eventualities over others (cf. the nucleus-satellite distinction in RST). A useful device for emphasis is the topic-comment structure: we mention the important event first, and then the others, which fill out or give further detail about that important event. These 'comments' on the 'topic' may be effects, but they could also be the cause of the topic. If the latter, then textual order and temporal order mismatch; the text is a causal explanation in such cases, and having only narrative discourse structure available would preclude its generation. Compare (1) and (2), modified from Hovy [1990].

- (1) First, Jim bumped Mike once and hurt him. Then they fought. Eventually, Mike stabbed him. As a result, Jim died.
- (2) Jim died in a fight with Mike. After Jim bumped Mike once, they fought, and eventually Mike stabbed him.

The textual order in (1) matches temporal order, whereas in (2) there is mismatch. And yet (2) is much better than (1). This is because the 'important' event is Jim's death. Everything mentioned in (1) leads up to this. But because the events are mentioned in their temporal order, the text obscures the fact that *all* the events led to Jim's death, even though syntactic markers like *and then* and *as a result* are used.

The causal groupings are clearer in (2) because it's clear during incremental processing that the text following the mention of Jim's death is a description of how it came about. This is so even though *no* syntactic markers indicate this causal structure. By contrast, in (1) the reader realises what's going on only at the last sentence. The discourse structure is therefore unclear until the whole text is heard, for the narrative requires a common topic which is only stated at the end.

States interact with causal information

In Lascarides and Oberlander [1991], we considered in detail the following pair of examples:

- (3) Max opened the door. The room was pitch dark.

(4) Max switched off the light. The room was pitch dark.

Now, no-one would want to say that (3) involved a room *becoming* pitch dark immediately after a door was opened. Rather, most accounts (such as those based in or around DRT, such as Hinrichs [1986]) will take the state of darkness to overlap the event of door-opening. That's how one might say states are dealt with in a narrative: events move things along; states leave them where they are. But if we have a piece of causal information to hand, things are rather different. In (4), it seems that the state *doesn't* overlap the previously mentioned event. If one wishes to preserve the assumption about the role of states in narrative, it would have to be weakened to the constraint that states either leave things where they are, or move them along. This is not a very convincing move. An alternative is to formalise the role of the additional defeasible causal knowledge. In generation, such knowledge will affect the space of adequate utterances; if *H* lacks the defeasible causal knowledge that switching off lights cause darkness, then (4) won't be adequate for *H*, who will interpret (4) in the same way as (3), contrary to *S*'s intentions.

The important point for now is that even if we describe things in the order in which they are assumed to happen, this doesn't necessarily make the candidate utterance a good one. If the speaker and the hearer possess differing world knowledge, there may be problems in retrieving the correct causal-temporal structure.

Two Methods of Generating with Defeasible Knowledge Generation by Defeasible Reasoning

There is a very general way in which we might view interpretation and generation in terms of defeasible reasoning. Consider the process of discourse interpretation as one of KB extension. The KB contains an utterance-interpretation, and a set of knowledge resources; the latter may include general knowledge of the world, knowledge of linguistic facts, knowledge about the discourse so far, and about the speaker's knowledge state. We then try to extend the KB so as to include the discourse interpretation. Consider now the process of generation; it

too can be thought of as KB extension. This time, the KB contains a temporal-causal structure, and a set of knowledge resources, perhaps identical to that used in interpretation. We now try to extend the KB so as to include a realization of the structure's semantic features (with predicates, arguments, connectives, orderings). This view might be described as *generation by defeasible reasoning*.

Modulo more minor differences, these notions are close to the ideas of *interpretation as abduction* (Hobbs et al [1988]) and *generation as abduction* (Hobbs et al [1990:26–28]), where we take abduction, for instance, to be a process returning a temporal-causal structure which can explain the utterance in context. Correspondences between a defeasible deduction approach and an abductive approach have been established by Konolige [1991]; he shows that the two are nearly equivalent, the consistency-based approach being slightly more powerful [1991:15–16], once closure axioms are added to the background theory.

Interactive defaults

We turn now to another, perhaps less powerful, method of applying defeasible reasoning: the Interactive Defaults (ID) strategy introduced by Joshi, Webber and Weischedel [1984, 1986]. Rather than considering the defeasible process as applying directly to the KB's causal network, we instead consider its role as constraining or debugging candidate linearised utterances, generated by some other process; here we will remain relatively neutral on the nature of that originating process.

A speaker *S* and a hearer *H* interact through a dialogue; a writer *S* and a reader *H* interact through a text. Joshi et al argue that it is inevitable that both *S* and *H* infer more from utterances than is explicitly contained within them. Taking Grice's [1975] Maxim of Quality seriously, they argue that since both *S* and *H* know this is going to happen, it is incumbent upon *S* to take into account the implicatures *H* is likely to make on the basis of a candidate utterance. If *S* detects that something *S* believes to be false will be among *H*'s implicatures, *S* must block that inference somehow. The basic way to block it is for *S* to use a different utterance; one which *S* does not

believe will mislead H .

In terms of defeasible reasoning, the point is that S must use it to calculate the consequences of the candidate utterance; if the process allows the derivation of something S believes to be false, the utterance should not be used in its current form. Joshi et al illustrate with the following example; given the KB in (5), and the question in (6), they want the process to show why the answer in (7b) is preferred to that in (7a):

- (5) Sam is an associate professor; most associate professors are tenured; Sam is not tenured.
- (6) Is Sam an associate professor?
- (7) a. Yes.
b. Yes, but he is not tenured.

We wish to assume this interactive defaults strategy (ID), and consider in detail the defeasible reasoning about causal-temporal structures that S and H are assumed by S to indulge in; and to consider which candidate utterances are eliminated on this basis.

ID with temporal constraints

The basic model in which we embed ID assumes that candidate discourses possess hierarchical structure, with units linked by discourse relations modelled after those proposed by Hobbs [1985]. Lascarides and Asher [1991] use *Narration*, *Explanation*, *Background*, *Result* and *Elaboration*. These structures have temporal implications, calculable via the nonmonotonic logic MASH proposed by Asher and Morreau [1991]. For instance:

- **Narration**

Clauses α and β that are discourse-related are normally such that $Narration(\alpha, \beta)$ holds.

- **Axiom for Narration**

If $Narration(\alpha, \beta)$ holds, and α and β describe the events e_1 and e_2 respectively, then e_1 occurs before e_2 .

Conflicts where one rule has a more specific antecedent than the other are resolved in favour of the more specific (this pattern of inference is known as the Penguin Principle). ID is exploited

within this logical framework to detect violations of constraints on these temporal implications; candidates violating the temporal constraints will be rejected (or debugged). We would urge that defeasible reasoning is a useful notion in generation only if an underlying notion of nonmonotonic logical consequence is defined. Otherwise, as argued in Lascarides and Oberlander [1991], the choice made among conflicting knowledge sources appears arbitrary. MASH provides a good starting point.

Following Bach [1986], we take ‘eventualities’ to cover both events and states. We define *temporal coherence*, *temporal reliability* and *temporal precision* in terms of a set C of relations between eventualities. This set intuitively describes when two eventualities are connected. The relations in C are: causation, the part/whole relation,¹ temporal overlap, and the immediately precedes relation (where ‘ e_1 immediately precedes e_2 ’ means that e_1 and e_2 stand in a causal or part/whole relation that is compatible with e_1 temporally preceding e_2).² The definitions are as follows:

- **Temporal Coherence**

A text is *temporally coherent* if the reader can infer that at least one of the relations in C holds between the eventualities described in the sentences.

- **Temporal Reliability**

A text is *temporally reliable* if one of the relations in C which the reader infers to hold does in fact hold between the eventualities described in the sentences.

- **Temporal Precision**

A text is *temporally precise* if whenever the reader infers that one of a proper subset of the relations in C holds between the eventualities described in the sentences, then she is also able to infer *which*.

A text is temporally *incoherent* if the natural interpretation of the text is such that there are no

¹We think of ‘ e_1 is part of e_2 ’ in terms of Moens and Steedman’s [1988] event terminology, as ‘ e_1 is part of the preparatory phase or consequent phase of e_2 ’.

²We assume that an event e_1 precedes an event e_2 if e_1 ’s *culmination* occurs before e_2 ’s. So there are part/whole relations between e_1 and e_2 that are compatible with e_1 temporally preceding e_2 .

inferred relations between the events. A text is temporally misleading, or as we shall say, *unreliable* if the natural interpretation of the text is such that the inferred relations between the events differ from their actual relations in the world. In addition, a text is temporally imprecise, or as we shall say, *ambiguous*, if the natural interpretation of the text is such that the reader knows that one of a proper subset of relations in C holds between the eventualities, but the reader can't infer *which* of this proper subset holds.

It follows from the above definitions that a text can be coherent but unreliable. On the other hand, there may be no question about reliability simply because we cannot establish a temporal or causal relation between the two eventualities.

Applying the ID strategy

Before applying ID with temporal constraints, we wish to mention the generation policies with which ID is compatible, and the possible relations between the knowledge of speaker S and that which speaker S has about hearer H 's knowledge state.

ID and generation policies

ID is quite neutral about generation policy, and applies to two main approaches to the generation of an appropriate utterance. Do we generate all possible utterances, and then apply defeasible reasoning, or do we generate candidates one at a time, and apply defeasible reasoning on each cycle? That is: is ID designed to constrain utterance space, or debug candidate utterances? Joshi et al explicitly adopt the latter view. In principle, their framework, however, is more general. Although the idea of debugging is intuitive, we shall sometimes talk in terms of constraining the space of utterances, rather than of debugging specific utterances.

Relative KBs

Let $B(S)$ be S 's beliefs about the KB, LK and WK. Let $B^+(H)$ be S 's beliefs about what H believes about the KB, LK and WK. And let $B^-(H)$ be S 's beliefs about what H doesn't know about the KB, LK and WK (so $B^+(H)$ and $B^-(H)$ are mutually exclusive). Problems concerning reliability and precision arise when $B(S)$ and $B^+(H)$ are different. They also arise when S 's knowledge of

what H believes is partial (i.e. when for some p used to generate an utterance, $p \notin B^+(H)$ and $p \notin B^-(H)$). Suppose that a WFF is relevant to generating a particular utterance about the KB. Then there are several possible relations between $B(S)$, $B^+(H)$ and $B^-(H)$ that concern p :

- **Case 1**

S knows p and also knows that H does not:
 $p \in B(S)$ and $p \in B^-(H)$

- **Case 2**

S knows p and isn't sure whether H does or not:
 $p \in B(S)$ and $p \notin B^+(H)$ and $p \notin B^-(H)$

- **Case 3**

H potentially knows more about p than S does:
 $p \notin B(S)$ and $p \notin B^+(H)$ and $p \notin B^-(H)$

- **Case 4**

S thinks H is mistaken in believing p :
 $p \notin B(S)$ and $p \in B^+(H)$

Of course, the case where $p \in B(S)$ and $p \in B^+(H)$ is unproblematic, and so glossed over here.

We look at each of these cases in turn, considering the extent to which the relations of reliability, coherence and precision help us constrain the utterance space (or alternately, debug candidate utterances).

Case 1: S knows more about p than H

We now examine the problems concerning reliability that arise when $p \in B(S)$ and $p \in B^-(H)$. There are two possibilities: either p represents defeasible knowledge of the language or the world, or p is some fact in the KB. We investigate these in turn.

p is defeasible knowledge Let p be a defeasible law that represents knowledge that S has and which S knows H lacks. To illustrate, take the case where p is the following causal preference concerning falling and pushing (introduced and formally represented in Lascarides and Oberlander [1991]):

- If the events e_1 of x falling and e_2 of y pushing x are connected, then normally e_2 caused e_1 .

Consider the case where John's pushing Max caused the latter to fall. Suppose S has a KB which

will allow her to generate the description in (8), among others.

(8) Max fell. John pushed him.

Elsewhere, we have argued that this text is coherent, precise and reliable for *S* because the causal law (about the usual causal relation between pushings and fallings) is more specific than the linguistic rule (*Narration*). But since *H* lacks the causal law, (8) will trigger a different inference pattern in *H*; one in which *Narration* wins after all. *S* must block this pattern by changing the utterance; she has essentially two options. If clause order is kept fixed, then *S* could shift tense into the pluperfect as in (9); or else *S* can insert a *clue word*, such as *because*, into the surface form, to generate (10):

(9) Max fell. John had pushed him.

(10) Max fell because John pushed him.

The success of the latter tactic requires *S* and *H* to mutually know a new linguistic rule, more specific than *Narration*, such as the following:³

• **Non-evidential ‘Because’**

A text segment α *because* β (where α and β are discourse-related clauses) is normally such that the event described in α is caused by the event described in β .

On the other hand, if clause order is not taken to be fixed, then *S* can simply reorder the sentences in (8):

(11) John pushed Max. Max fell.

So, when *S* believes *H* lacks the relevant causal law, *S* can simply reorder, and let *Narration* do the rest. However, recalling the above discussion, in some cases a discourse structure that invokes *Explanation* is better than one that invokes *Narration*. So simply reordering events and letting the rule for *Narration* achieve the correct inferences won’t work successfully in all cases.

Furthermore, recalling the discussion about states and causation above, it becomes apparent

³This is a pragmatic, rather than semantic rule; it’s not obvious that this is the best choice of representation.

that this tactic of always letting *Narration* do the work will lead to problems with texts like (3) and (4).

(3) Max opened the door. The room was pitch dark.

(4) Max switched off the light. The room was pitch dark.

The reason is that, in the absence of the causal law which relates light switching to darkness, (4) will be analysed exactly as (3), giving the wrong result. A solution would be to replace the state expression with an event expression:

(4′) Max switched off the light. The room *went* pitch dark.

An obvious alternative is to introduce further clue words, and appropriate linguistic rules for reasoning about them. This means exploiting linguistic knowledge to overcome the gaps in *H*’s world knowledge. This helps explain the observation that texts which describe events in reverse to temporal order, without marking the reverse, may be quite rare. It’s easy enough to interpret such texts, when we have the appropriate WK. But if a considerate speaker or writer has reason to believe that some or all of her audience lacks that WK, then she will either avoid such descriptive reversals, or mark them with the type of clues we have discussed.

***p* is a fact in the KB** We now turn to the case where *p* is a fact about the KB which *S* knows and which *S* knows *H* lacks. Suppose that *p* asserts a causal relation between two events that does not represent an exception to any defeasible causal preferences. Then *S* can simply state *p* by exploiting *H*’s available LK. Clue words may not be needed. For example, if *p* is the fact that Max stood up and then John greeted him, *S* can tell *H* this by uttering (5); *Narration* will make (5) reliable and precise for *H*.

(5) Max stood up. John greeted him.

Similarly, if *p* is the fact that Max opened the door, and while this was going on the room was pitch dark, then (3) is reliable and precise for *H*:

(3) Max opened the door. The room was pitch dark.

But what if p asserts a causal relation between two events that violates a defeasible causal preference that H has? Suppose p asserts that Max's fall immediately preceded John's pushing him. And suppose that S knows that H has the defeasible causal law, but lacks p . Then neither (8) nor (11) are reliable for H , indicating that S cannot generate an atomic text to assert p .

(8) Max fell. John pushed him.

(11) John pushed Max. He fell.

The obvious option is to move from (8) to (12); another option is to recruit the pluperfect, as in (13); note that (14) is *not* the solution, since *so* can be read epistemically (evidentially).

(12) Max fell. And then John pushed him.

(13) John pushed Max. He had fallen.

(14) Max fell. So John pushed him.

The need to utter (12) rather than (8) explains why it can be necessary to use *and then*, even though the full-stop is always available and, by *Narration*, has the default effect of temporal progression. So, in general, one might wish to paraphrase Joshi et al: if a relation can be defeasibly inferred to hold between two eventualities, and S wants something different, it is essential to *mark* the desired relation with something stronger. Having a little causal knowledge is sometimes worse than having none at all.

Case 2: S knows p but isn't sure if H does

In general, S will have only partial knowledge about H 's beliefs.

p is a defeasible causal preference Suppose that S isn't sure whether or not H believes the defeasible causal law relating falling and pushing. Then there are at least two ways in which S 's model of H 's knowledge can be expanded to a complete statement of H 's knowledge. The first, B_1 , contains the causal law. The second, B_2 , does not.

If S assumes H 's knowledge corresponds to B_1 , then H will find a reliable interpretation for (8).

(8) Max fell. John pushed him.

On the other hand, if S assumes that H 's knowledge corresponds to B_2 , then H will interpret (8) in an undesirable way, with the falling preceding the pushing.

Under this model, S isn't sure how H will interpret (8), because S doesn't know if H 's knowledge corresponds to B_1 or B_2 . Hence the ambiguity of (8) manifests itself to the generator S , if not to the hearer H , because S doesn't have sufficient information about H to predict which of the two alternative temporal structures H will infer for (8). This is slightly different to the previous case where S actually *knows* H lacks the causal law, making (8) unreliable.

To avoid uttering unreliable text, S will have to utter something other than (8). Indeed, it may be possible for S not to worry about the ambiguity of (8) at all, if some 'safe' strategy can be found that would guide S 's expansion of H 's knowledge in a way that would ensure the generation of reliable text for H . A plausible strategy for S 's reasoning about H would be the following: if S isn't sure whether or not H knows p , then assume H doesn't know p . On the face of it this seems plausible. But just how safe is it?

We state it in terms of $B^+(H)$ and $B^-(H)$:

- If $p \notin B^+(H)$ and $p \notin B^-(H)$, assume $p \in B^-(H)$ and generate-and-test under this assumption.

But this won't work in general. If S wants to convey a violation of the causal law p , but H actually believes p , then the strategy will suggest the use of (8), which will actually be unreliable for H .

By and large, S will have to consider several alternative expansions of H 's knowledge. As a result, ambiguity of text will manifest itself to S in certain cases, because of her partial knowledge of H . This is perhaps somewhat surprising. Non-monotonic reasoning is designed as a medium for reasoning with partial knowledge. And yet here we have shown S cannot maintain textual reliability

on the basis of a partial statement of H 's KB, even if nonmonotonic inference is exploited.

p is a fact about the KB: Ambiguity Suppose that S wants to convey the information that Max's fall immediately preceded John pushing him, and suppose S knows that H knows the causal law, but S doesn't know for sure if H knows already that Max fell *before* John pushed him. Then, for similar reasons as those mentioned earlier, S isn't sure if (8) is reliable or not.

(8) Max fell. John pushed him.

To be sure that text is reliable in this case, S will again have to exploit linguistic knowledge; for example, by uttering (12) instead of (8).

(12) Max fell and then John pushed him.

These examples show that a little knowledge of H is a dangerous thing.

Case 3: H as advisor, S as pupil

Suppose that for a certain proposition p , $p \notin B(S)$, $p \notin B^+(H)$ and $p \notin B^-(H)$. This corresponds to H potentially knowing more about p than S , but S not knowing what more. That's pretty much the position of the tutee in a tutorial dialogue, and the advice-taker in an advisory dialogue.

Case 4: S thinks that H is mistaken

Suppose that $p \notin B(S)$ and $p \in B^+(H)$. Then S doesn't believe p even though he's aware that H does. This implies that S thinks H is mistaken in the belief that p .

The fact that $p \notin B(S)$ and $p \in B^+(H)$ could entail that a text that's reliable for S isn't for H . For example, suppose that H believes, by some weird perception of social convention, that there is a defeasible causal preference that greetings cause standing ups. Suppose that S wants to describe the situation where Max stood up and then John greeted him (i.e. an exception to H 's causal preference). Then this is like the exception case above concerning falling and pushing: (15) is reliable for S but not for H .

(15) Max stood up. John greeted him.

Again, S could compensate for this by explicitly marking the temporal relation. Alternatively, the fact that $p \notin B(S)$ and $p \in B^+(H)$ could entail that a text that's *unreliable* for S is reliable for H . Again, let p be the causal law that says that greetings cause standing ups. But this time suppose that S wants to describe the situation where John's greeting Max caused him to stand up. So this time, S wants to describe an instance of the causal law. Then both (15) and (16) are reliable for H , but only the latter is reliable for S .

(16) John greeted Max. He stood up.

Since (15) is unreliable for S , it would not be in the set of possible linguistic realisations, if this set is characterised by what S finds reliable, as we've assumed so far. So perhaps this set should be constrained by considering $B^+(H)$ from the start.

Conclusions

Here, we summarise the current shape of the model, and briefly discuss one of its potential shortcomings.

We admitted that that job of defeasible reasoning in generation could be very general; but that we were going to look at it in the context of the Interactive Defaults strategy. We assumed that some process took messages, and produced ordered utterances, in accordance with (for example) topic-comment strategies. ID then applies to the candidate utterances (or the space of utterances), and criticises the utterances (or the space), producing better utterances, or a smaller space. The grounds for criticism we discussed were the temporal ramifications of the utterance; if it was incoherent for H , unreliable for H or dangerously ambiguous (for S), it was a bad utterance.

Discourse structure and temporal structure are here somewhat detached. The discourse structure was used in determining the original sequencing; but now it's only the causal-temporal structure derivable from the candidate that is being criticized. It may therefore be thought that the discourse structure is an idle wheel as things stand, and should be either eliminated (cf. Sibun [1991]), or be trusted with a greater share of the work, enriching the discourse with useful clue words [cf.

Scott and Souza [1990]). Our tentative view is that the latter view is perhaps correct, and anyway is closer to the idea of generation by defeasible reasoning, canvassed early on. It's true that simplest is sometimes best. But it does seem like a lot of hard work to generate simple candidates which almost always require debugging, when we could instead do all the work in advance, by default.

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